

Culvert Design Process

Hydrology



Site Assessment



Alignment and Profile



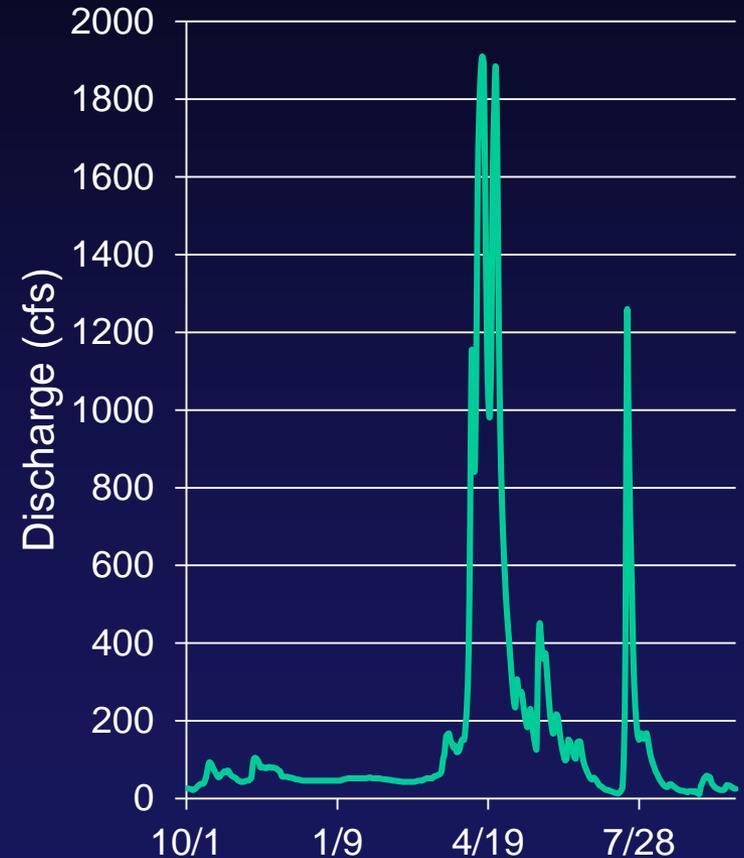
Bed and Banks



Structure



Sediment Mobility & Stability



Hydrology

- Estimate flood flows
- Estimate by-pass flows

Hydraulic analysis requires hydrologic data

- Wide range of flood flows to evaluate:
 - Peak hydraulic capacity, 100-yr flood (check 500-yr flood)
 - Sediment mobility and stability, $<Q_{1.01}-Q_{500}$

100-yr flood = 1% exceedance probability each year
2-yr flood = 50% exceedance probability each year

- Hydrology data are also needed for:
 - By-pass flows during construction
 - Site assessment, Fishxing, Bankfull verification

Hydrology concepts and terms

- Streamflow data
 - Collected at streamflow gaging stations
 - 2 types of sites: continuous and crest gage
 - Used to estimate flows at ungaged sites
- Data are analyzed for:
 - Flood frequencies (all gage types)
 - Ave daily flows (continuous recording gages)
 - Flow duration curves
 - Monthly flows

National Streamflow Statistics (NSS) program



The National Streamflow Statistics Program: A Computer Program for Estimating Streamflow Statistics for Ungaged Sites

Chapter 6 of
Book 4, Hydrologic Analysis and Interpretation
Section A, Statistical Analysis



Techniques and Methods 4-A6

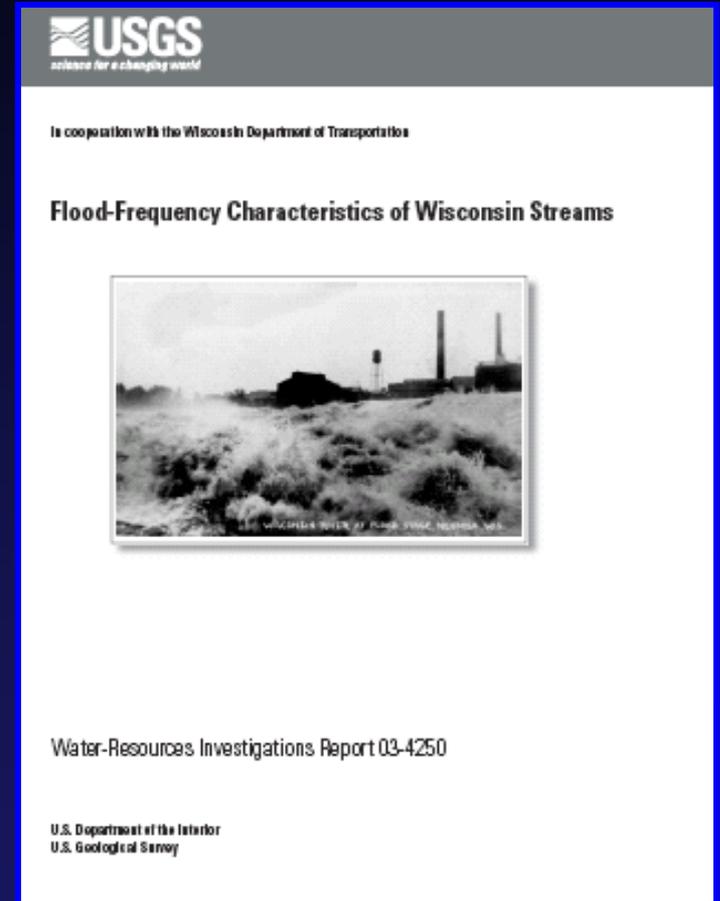
U.S. Department of the Interior
U.S. Geological Survey

- Summary of flood frequencies at gage stations
- Methods for extrapolating data to ungaged sites
- Regional equations for flood frequencies and other streamflow statistics
- Computer Program: Version 6
 - Download software
 - Technical papers for each State
 - Latest equations for each State

<https://water.usgs.gov/software/NSS/>

Technical publications for each state

Publications are available from the U.S. Geological Survey at the website listed below.



https://water.usgs.gov/osw/programs/nss/NSSpubs_Rural.html



Location of Streamflow-Gauging Stations, Crest-Stage
Partial-Record Stations, and Regulated Stations in Wisconsin
by J.E. Walker and W.R. Krug 2003

Rural sites

Walker and Krug
(2003).

Flood Frequency
Characteristics
of Wisconsin
Streams.

USGS WRI-
Report 03-4250

ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS FOR WISCONSIN URBAN STREAMS



Urban sites

Conger, D. H.
(1986).

Estimating
Magnitude and
Frequency of
Floods for
Wisconsin
Urban Streams.

USGS WRI-
Report 86-4005

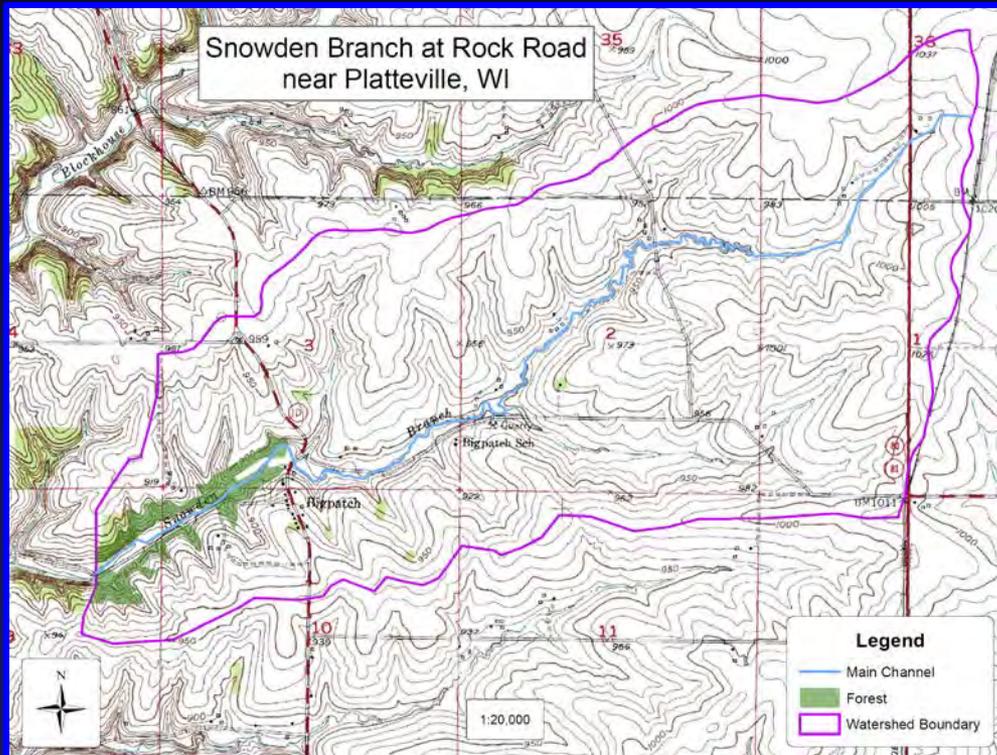
Flood estimate and prediction error



Hydrology

- Drainage Area
 - Delineate drainage area
 - Determine watershed characteristics
- Flood flow estimates
 - Estimate flood flows
 - Select design frequency

WS area and characteristics



Drainage area = 3.48 sq mi

Forest = 2.41%

Channel slope = 41.2 ft/mi

Ppt 25-yr 24-hr = 5.29 in

Snowden Branch at Rock Road

- WI Area 1

$$Q_2 = 99.9(A)^{0.652} \text{ FOR}^{-0.254} I_{25}^{7.52} \quad \text{SE: 43\%}$$

$$Q_{100} = 44.2(A)^{0.893} \text{ FOR}^{-0.312} I_{25}^{7.56} S^{0.571} \quad \text{SE: 44\%}$$

- Results:

- 100-yr = 1,470 cfs (422 cfsm)
- 2-yr = 315 cfs (91 cfsm)
- 1.5-yr = 210 cfs (60 cfsm)



Urban sites

Flood-frequency equations for Wisconsin
Urban areas:

$$Q_{100} = 32.8 A^{0.704} I^{0.770} \text{ (Standard error 37\%)}$$

Where A = Area and I = Impervious area

Land Use Category	Total impervious area (%)		
	Low	Med	High
Single-family residential	16	27	45
Multi-family residential	50	60	70
Commercial	80	88	96
Industrial	50	75	90
Public facilities	50	60	75
Parks and undeveloped	0	1	3

Conger, D. H.
(1986).

Estimating
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National Streamflow Statistics (NSS) program

National Streamflow Statistics (NSS)

File Graph Help

Analysis Type: Peak Probability Other

State: Wisconsin Site Name: unnamed

Rural

Rural 1 New Edit Delete

Rural 1
Basin Drainage Area: 3.48 square miles
1 Region
Region: Area_1
Drainage_Area = 3.48 square miles
24_Hour_25_Year_Precipitation = 5.29 inches
Stream_Slope_10_and_85_Method = 41.2 feet per mi
Percent_Forest = 2.41 percent

Statistic	Value, ft3/s	Estimate Error, %
PK2	315	43
PK5	631	40
PK10	714	38
PK25	990	40
PK50	1220	42
PK100	1470	44
PK500	1960*	

*Extrapolated value

Urban

Urban 2 New Edit Delete

Urban 2
Basin Drainage Area: 0.64 square miles
1 Region
Region: Wisconsin_Urban_Areas
Drainage_Area = 0.64 square miles
Percent_Impervious = 48.7 percent

Statistic	Value, ft3/s	Standard Error, %
PK2	155	37
PK5	246	32
PK10	304	32
PK25	376	33
PK50	427	35
PK100	477	37
PK500	585*	

*Extrapolated value

Frequency Plot Hydrograph Weight

National Streamflow Statistics (NSS) program

Edit Scenario

Scenario: Rural 1 Total Basin Drainage Area: 3.48 mi²

Region	Data Source	URL (Click to access)
Area_1	Walker, J.F., and Krug, W.+	http://pubs.usgs.gov/wri/wri+
Area_2	Walker, J.F., and Krug, W.+	http://pubs.usgs.gov/wri/wri+
Area_3	Walker, J.F., and Krug, W.+	http://pubs.usgs.gov/wri/wri+
Area_4	Walker, J.F., and Krug, W.+	http://pubs.usgs.gov/wri/wri+
Area_5	Walker, J.F., and Krug, W.+	http://pubs.usgs.gov/wri/wri+

Variable	Area_1
Drainage_Area (square miles)	3.48
24_Hour_25_Year_Precipitation (inches)	5.29
Stream_Slope_10_and_85_Method (feet per mi)	41.2
Percent_Forest (percent)	2.41

Crippen & Bue (1977) flood region: 6 Map...

OK Cancel

Flood flow exercise

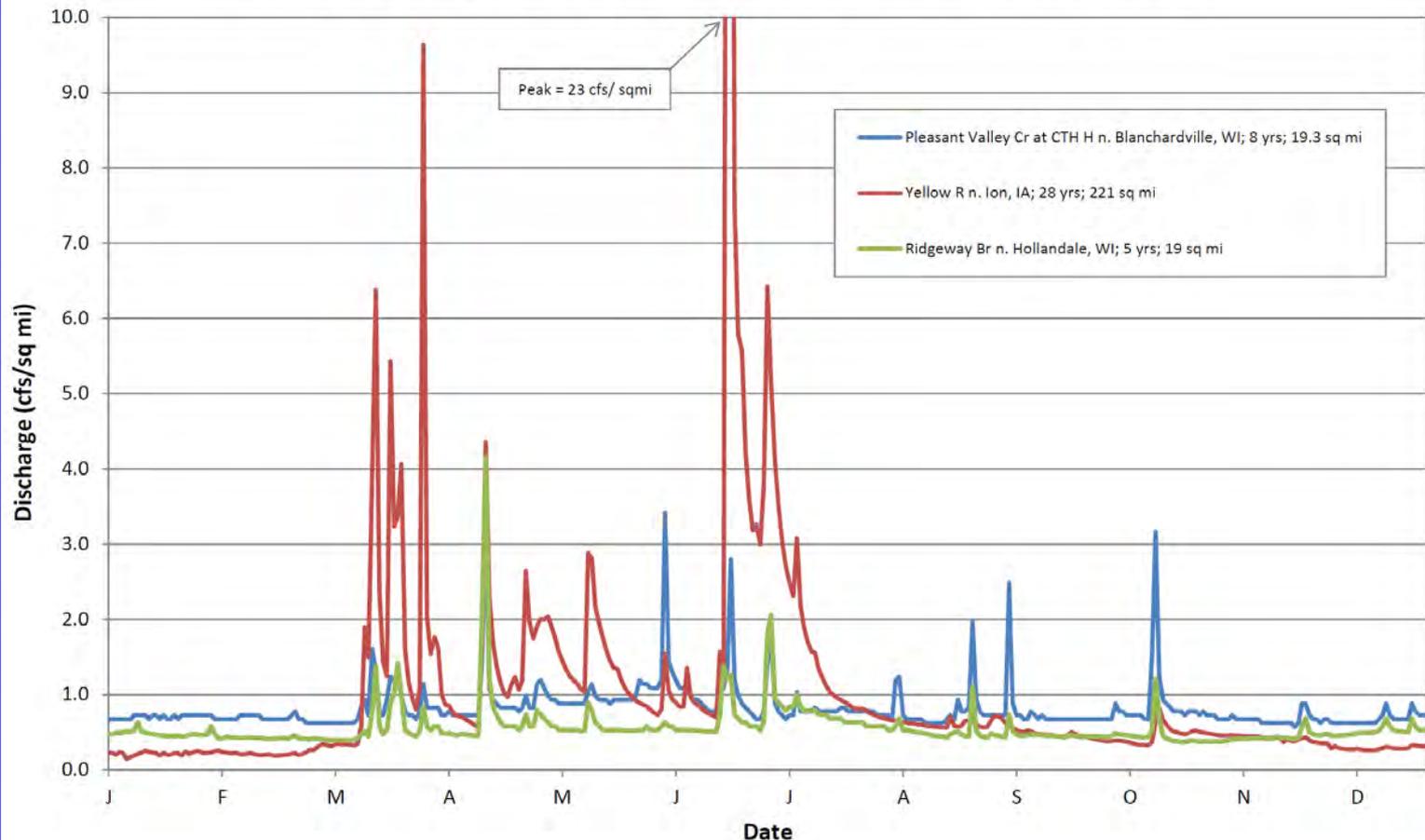
Hydrology

By-pass flows

- Determine construction period
- Select typical and upper by-pass flows from flow duration curve or monthly flows

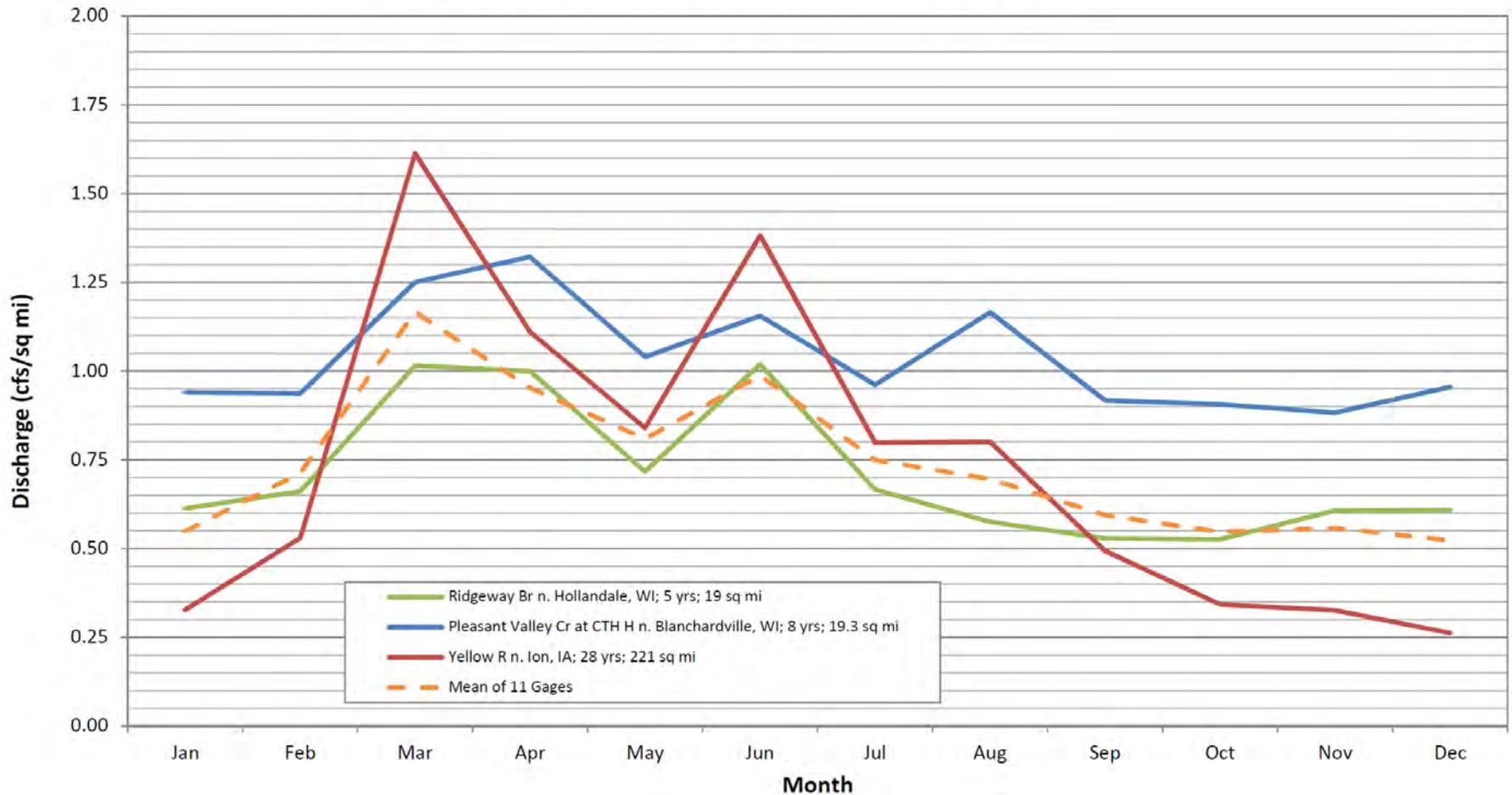
Ave daily runoff for watersheds near Platteville WI

Average Daily Flow for 3 Gages Near Platteville, WI for 2014



Ave monthly runoff near Platteville, WI

Average Monthly Flows for Platteville, WI Area



By-pass flow: Pumping estimate based on average monthly flow

Unt Rountree Site, Drainage Area = 0.64 sq mi

July Ave Flow = $0.75 \text{ cfs/sq mi} \times 0.64 \text{ sq mi} = 0.48 \text{ cfs}$
or 215 gal/min



By-pass flow: Diversion pipe

Trout Tributary at County U

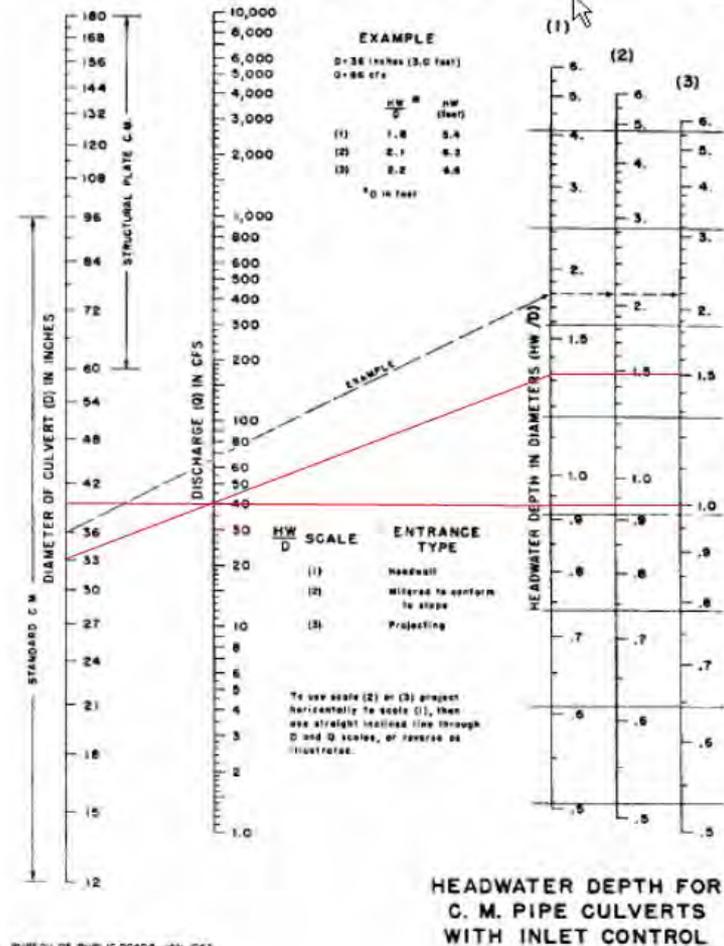
Drainage area = 4.19 sq mi

$$Q_2 = 40 \text{ cfs}$$



Trout Trib at Cty U
Bypass
Circular CMP
Q2 = 40 cfs

CHART 2B



By-pass flow exercise